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This paper reports the results of attempts to model the spectral properties of the lunar regolith as consisting of crystalline rocks, glass and submicroscopic metallic iron (SMFe), produced by a process involving vapor phase differentiation. The models differ in the location of the SMFe.

The lunar regolith differs from crystalline rocks and glasses of similar composition in having a lower albedo, redder continuum spectrum and more subdued absorption bands. Early melting experiments [1,2,3] seemed to indicate that these properties could be accounted for by simple vitrification. However, the oxygen fugacities in these experiments were below the Fe-wustite boundary, so that they do not simulate lunar impact vitrification. Glasses made at low fugacities have high albedos and strong absorption bands [4,5,6,7], so that some other component of the soil must be responsible for its optical properties.

It has been suggested [5,7] that SMFe is the cause of the low albedo of the moon, and that the SMFe is made by chemical differentiation accompanying the deposition of vapors within the regolith created by solar wind sputtering and impact vaporization. The rates at which vapor and melt glass are generated on the lunar surface are not significantly different, and most of this vapor is trapped in the soil, rather than escaping from the moon. Although the differentiation has been verified by laboratory experiments [5,6,7], it has not been widely accepted because of the apparent lack of vapor condensates in lunar soil. However, Keller and McKay [8,9] have detected vapor deposited coatings ~ 100 nm thick on soil particles. As predicted from laboratory simulations [5], these coatings are enriched in Si and Fe, much of the latter being SMFe, although whether they are present in sufficient amounts to cause the darkening is not yet clear.

I have attempted to determine whether the SMFe can indeed account for the lunar optical properties, as hypothesized. Several theoretical models were calculated in which the SMFe was assumed to be in different locations in the soil, including (1) bare SMFe on the surfaces of the grains, (2) SMFe-containing silicate coatings on all grains, (3) SMFe inside the glass particles only, and (4) SMFe distributed throughout the glass and also coating the crystalline grains. The models all had 50% crystalline rock, 50% vitrified rock and 0.5% SMFe. The best match to the actual soil spectrum was model 4, as shown in the figure.

Based on these results, it is proposed that on the lunar surface soil particles, consisting of both crystalline and vitrified material, become partially coated with vapor-deposited glass containing SMFe. Subsequent impacts partially fuse the coated particles together, forming agglutinates in which the SMFe is distributed throughout the particle. This process would be important on the moon and Mercury, but not in the asteroid belt.

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